Measurements of Atmospheric and Oceanic Parameters Affecting Brightness Temperature in Passive Microwave Radiometry

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LONG-TERM GOAL

We wish to improve our understanding of the measurement of brightness temperature and its relation to wind speed and direction and/or wind stress vector.

SCIENTIFIC OBJECTIVES

1. Examine space/time variability of directional properties of surface waves and wind stress and its relation to brightness temperature.

2. Investigate changes in emissivity with respect to surface roughness, foam coverage and breaking.

3. Explore how other environmental parameters such as rain, water vapor, salinity, temperature affect brightness temperature.

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4. Explore scattering issues due to large-scale waves as a function of incidence angle, Bragg type scattering and sea foam.

5. Examine how wind direction signals could be extracted in the microwave brightness temperature measurements over a wide range of frequencies, incidence angles and wind speeds.

APPROACH

The cluster of three ASIS buoys measured air-sea interaction parameters, directional wave spectra, near-surface turbulence and acoustic ambient noise (Graber *et al*. 2000). This data will be processed to determine the space/time variability of directional wave properties and wind stress vectors over a typical satellite resolution cell. The in-situ buoy data will be combined with both airborne and satellite (SSM/I) passive microwave measurements to examine which and how atmospheric and oceanic parameters affect brightness temperatures. These data sets will used to establish the ranges of the temporal and spatial variability of the wind and wave parameters. The results would allow us to examine the relationship between a temporal and spatial average and the validity of invoking the “frozen-turbulence” hypothesis in satellite and buoy comparisons. While wind speed is more readily related to brightness temperature, wind direction is more difficult to achieve and requires full polarimetric remote sensing. From the correlation of directional properties of surface waves and wind stress with the three buoys we will address the modulation characteristics of Bragg waves for different wind and wave conditions and how other environmental parameters might affect the brightness temperature.

In order to establish the space/time characteristics of the atmospheric and oceanic variables from the buoys in conjunction with the airborne brightness temperature measurements we will use wavelet techniques. Although wavelet transforms lack the fine-scale frequency resolution of Fourier methods, they are especially useful to resolve temporal variations. Specifically we can address what time scales of the wind forcing were present during aircraft overflights and if there are differences from observation to another. In particular we will use the wavelet directional method (WDM) to study the variability of the high-frequency waves of the wavenumber direction spectrum within the domain of the equilateral triangle.

WORK COMPLETED

1. All oceanographic and meteorological measurements have been processed and mean values over suitable averaging intervals have been computed.

2. Directional wave spectra using both MLM and WDM techniques have been computed.

3. Selection of times with coincident buoy and airborne and satellite passive microwave measurements have been identified. Satellite images from SSM/I are in hand for these times and airborne observations are currently processed.

4. Preliminary comparisons with SSM/I overflights have been made and presented at IGARSS 2001 in Sydney, Australia.

RESULTS

For six weeks (March/April 1999) the three ASIS buoy systems were deployed in the northeastern part of the Gulf of Mexico. The spar buoys were deployed in an equilateral triangle with ~15 km on a side. At the center of the triangle was an NDBC 3-m discus buoy.

Figure 1 on the left, shows the spatial variability of near-surface water temperature from three buoys separated by about 15 km during the pre-WindSat airborne cal/val and on the right, we present time series of salinity at the ASIS buoys. It's noteworthy to highlight the differences of as much as 1 psu over a 15 km distance.

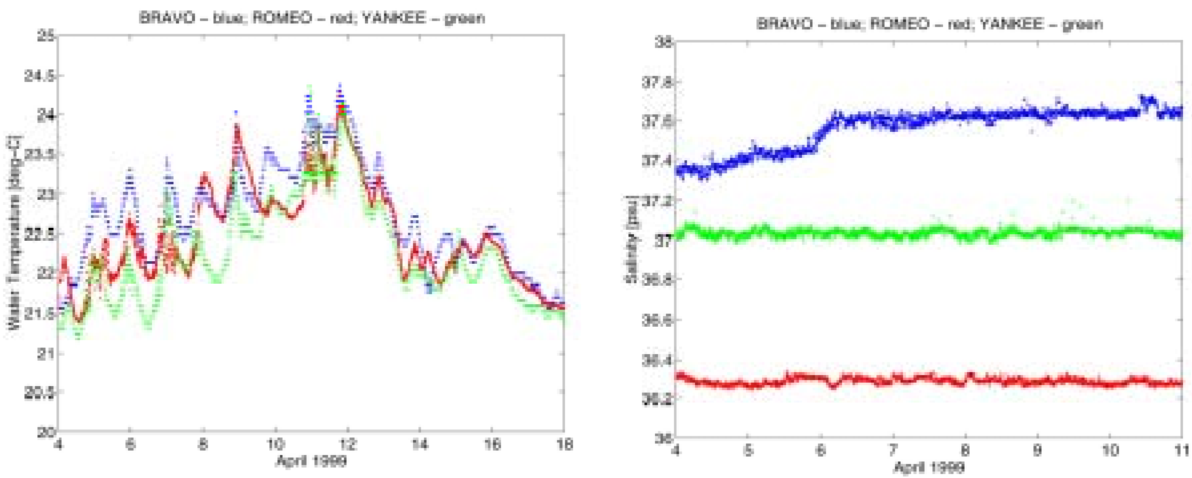

Figure 1: Left: A two week time series of near-surface water temperature obtained from the three ASIS buoys. Note the considerable variability in temperature of almost 2 ^{o}C. Right: A one week time series of salinity obtained from the three ASIS buoys. Note the considerable gradient of 1 psu over a 15 km distance.

Similar small scale variability is also observed in the wind field, where differences can amount to as much as 5 m/s and more, especially during frontal passages. Figure 2 shows a times series of wind speeds at the three ASIS buoys and wind speeds derived from the closest cell of SSM/I brightness temperature measurements. In some cases the SSM/I and ASIS winds agree quite well, while in other situations there differ considerably. We will examine further the cause of these differences, in particular how much could be attributed to spatial averaging by the satellite.

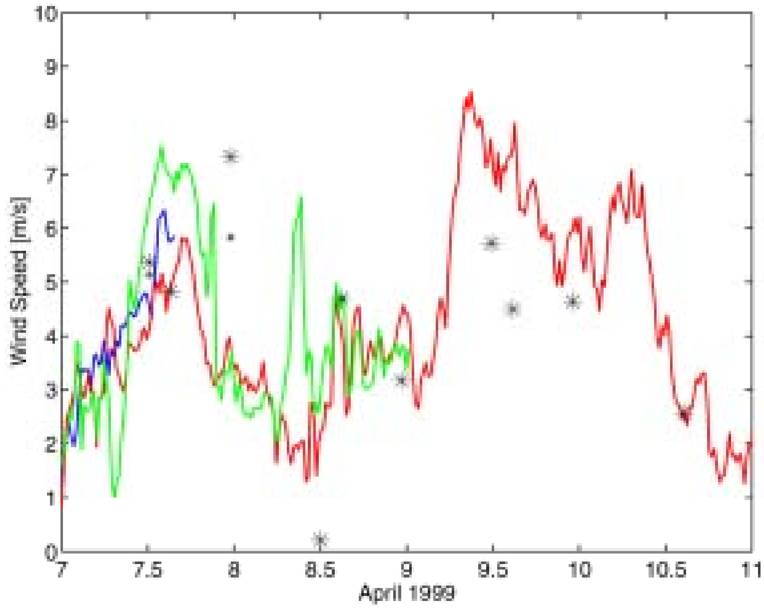

Figure 2: Time series of wind speed from the three ASIS buoys. Colocated SSM/I wind speeds (*) are also plotted. Note large differences during the passage of frontal systems.

Figure 3 shows a scatter plot of ASIS winds and SSM/I wind speeds. The bias of 0.4 m/s is quite small, while the rms difference of 1.6 m/s is within the accuracy of the satellite data. However, a few notable outliers exist and warrant further examination.

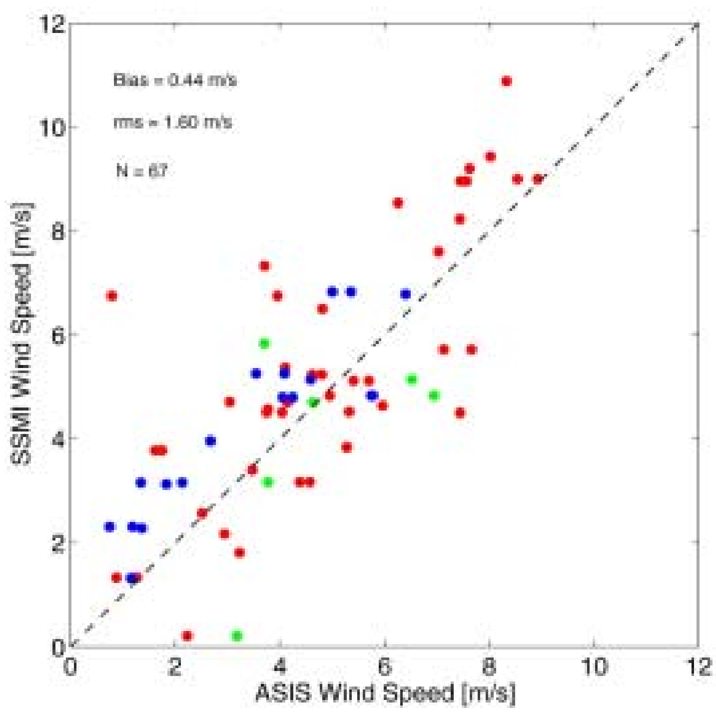

Figure 3: Scatterplot of ASIS and SSM/I wind speeds.

Figure 4 on the left, shows the spatial wind speed variability over the deployment region of the ASIS buoys on 7 April 1999 at 23:31 UTC. Note the pocket of strong winds near the buoys which indicate much lower wind speeds (~3.7 m/s). The right panel shows the spatial variability of the brightness temperature for the 22 and 37 GHz channels for both V and H polarization. While they show gradients too, they are not necessarily consistent with the satellite wind speeds on the left. One can speculate to what extent other parameters may play a role in obtaining the true wind speed from satellite data.

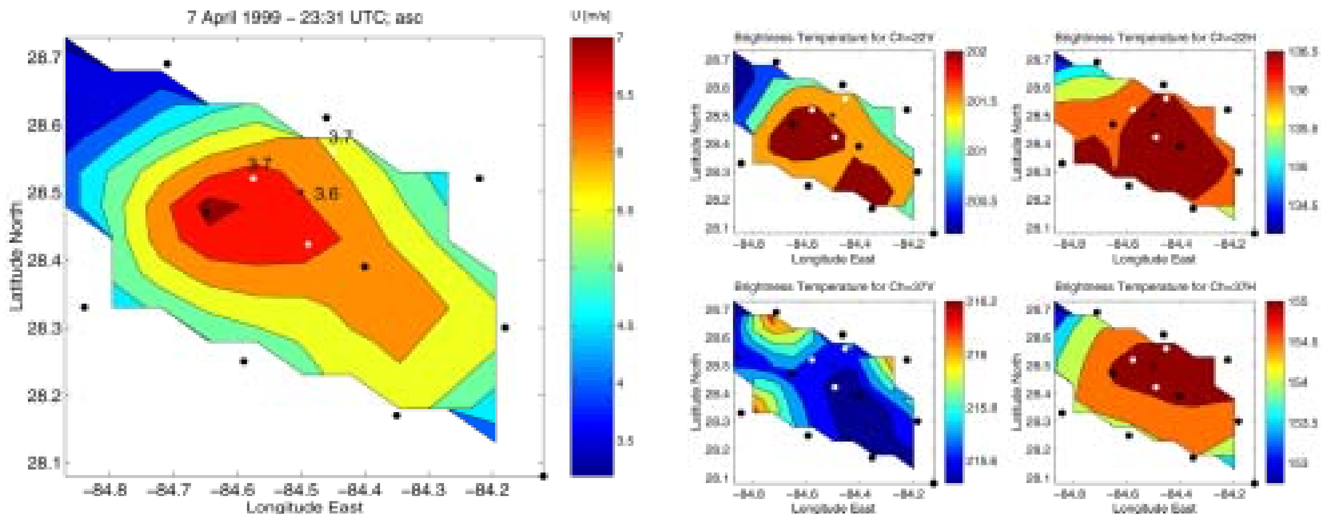

Figure 4: Left: Spatial variability of SSM/I wind speed estimates for 7 April 1999 at 23:31 UTC for an ascending pass. The buoy observations are indicated by the white dots and the numbers next to it in m/s. Right: The spatial variability of brightness temperature for channels 22 and 37 GHz and H and V polarization during the same time. Location of buoys are given by white dots for reference.

IMPACT/APPLICATION

We expect that the results of this study would considerably enhance the goals of the Navy's SSMI-S and WinSat programs. In particular we expect a better understanding of the relation of brightness temperature to environmental parameters and the spatial/temporal variability of oceanic and atmospheric parameters over typical satellite resolution cells.

TRANSITIONS

None yet.

RELATED PROJECTS

The ASIS buoys will be deployed during the validation phases of the DMSP SSMI-S and WindSAT satellites. The project on "Measurements of Surface Wave Properties and Marine Fluxes Affecting Directional Signatures of Polarimetric Sea Surface Brightness Temperature" was funded by the NPOESS/IPO program.